PATENT SPECIFICATION (11) 1 344 002

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(21) Application No. 21491/71 (22) Filed 19 April 1971 (19)

(31) Convention Application Nos. 20261 (32) Filed 3 March 1970
20262 3 March 1970
32263 6 April 1970
108 908 4 Nov. 1970 in

(33) Japan (JA)

(44) Complete Specification published 16 Jan. 1974

(51) International Classification B60C 23/02 23/04

(52) Index at acceptance
B7C 71A

(54) TIRE PRESSURE INDICATION SYSTEM

(71) I, UICHIRO SUGIYAMA, of Japanese nationality, of 21—10, Zenpukuji 1-chome, Suginami-ku, Tokyo, Japan, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a tire pressure indication system for providing an alarm in the driver's compartment of a vehicle when the pressure in a tire of the vehicle falls to or below a predetermined value.

According to the invention there is provided a tire pressure indication system including: a pressure sensitive arrangement contained wholly within a vehicle tire or arranged outside the tire and in gaseous communication with an inflation valve of the tire, the pressure sensitive arrangement comprising a diaphragm arranged to move when the tire pressure changes and a member connected with the diaphragm so as to be moved when the diaphragm moves; a signal transmission unit comprising a magnet arranged to be controlled by said member, the pressure sensitive arrangement and the magnet being mounted for rotation with the tire and the signal transmission unit also comprising a reed switch for arrangement on a non-rotatable part of the vehicle adjacent to the rotational path of the magnet; and an alarm indication unit for location in a driver's compartment of the vehicle, said alarm indication unit incorporating means for alarm indication and an electrical circuit having a thyristor, said alarm indication unit being connected to said reed switch which is operable, when arranged as aforesaid, and when the tire is rotating, to be closed by said magnet to operate said thyristor and thus the alarm indication means in response to movements of said diaphragm and consequently said member caused by a pressure reduction in the tire to or below a predetermined value.

The magnet and reed switch respectively can be surrounded by plastics and epoxy resin to protect them from the external conditions.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a cut-away radial section of a wheel and tire assembly fitted with a pressure sensitive arrangement and an electric signal transmisison unit in accordance with a first embodiment of the present invention;

Figure 2 is a cut-away side view of part of the assembly shown in Figure 1;

Figure 3 is a section view of the pressure sensitive arrangement of Figure 1;

Figure 4 is an electric wiring diagram of the tire pressure indication system of Figures 1 to 3;

Figure 5 is an electric wiring diagram of the tire pressure indication system of Figures 1 to 4 in a four-wheel vehicle;

Figures 6 to 8 show a tire pressure indication system in accordance with a second embodiment of the present invention, in which Figure 6 is a radial section of a wheel and tire assembly showing an overall view of the system of the second embodiment;

Figure 7 is a section showing the working arrangement of the pressure sensitive arrangement and magnet of the second embodiment and indicating the working condition at the time of a satisfactory tire pressure;

Figure 8 is a view similar to Figure 7 but indicating the condition at the time of a pressure reduction to or below a predetermined undesirable value;

Figures 9 to 12 show a tire pressure indication system in accordance with a third embodiment of the invention, in which:

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Figure 9 is a radial section of a wheel and tire assembly showing the way in which apparatus of the present invention is mounted on the tire;

Figures 10 and 11 are enlarged sections taken along the line A—A of Figure 9 showing the pressure sensitive arrangement and magnet when satisfactory and unsatisfactory respective tire pressures prevail;

Figure 12 is a diagram showing the circuit of the system of the third embodiment of the present invention;

Figure 13 shows a detail of the apparatus shown in Figures 7 and 8; and

Figure 14 is a partially sectioned view of the bleed element 34 of Figure 6.

Figures 1 to 4 show a first embodiment of tire pressure indication system. First, a pressure sensitive arrangement in the form of a unit 1 is mounted inside a pneumatic tire of a vehicle and allows air to enter the unit from the tire through a hole 2 in the unit. The air so introduced acts on a diaphragm 3 against an adjustable biasing spring 4, and at pressures above a predetermined value will move the diaphragm 3 sufficiently to open a switch 5, the switch 5 being allowed to close when the tire pressure falls below the predetermined value. This unit 1 is arranged along the base of a wheel rim 6 and secured thereto with a bolt. A signal transmission unit 7 is provided of the switch system type in which control is effected by a magnetic force between a magnet 8 and a reed switch 9, both of which are surrounded by plastics and epoxy resin. The magnet 8 is an electromagnet and is secured by a bolt in a suitable position on a wheel hub 11 in a brake drum 10. A mercury battery 14 is provided in a casing 13 of a battery body 12 and the battery body 12 is provided with a contact 16 which, on rotation of the wheel, is closed by a weight 15 subjected to centrifugal force due to the rotation. The battery body 12 is mounted in a suitable position on the axially outer face of the wheel, displaced from the centre of the wheel, with a hub bolt 17. The contact 5 of said pressure detection unit 1, the contact 16 of the battery body 12 and the magnet 8 on the side of the rotating tire are connected in series thereby exciting the magnet 8 when there is a sufficient pressure reduction in the tire so that the contact 5 is closed, and the tire is rotating so that the contact 16 is closed. The reed switch 9 of the signal transmission unit 7 is removably secured by means of a fitting member 18 and a bolt 20 in a suitable position on the non-rotatable back plate 19 to provide a clearance of about 2 mm. between the magnet 8 and the reed switch 9 on a back plate 19. In an electric circuit (see Figure 4) of an alarm indication unit 21 mounted in the driver's compartment of the vehicle, an electric source 22, a pushbutton switch 23 which is normally closed, an alarm buzzer 24, and the anode and cathode of a non-return three terminal type thyristor (SCR) 25 are connected in series thereby forming a closed circuit. The buzzer 24 is connected to a lamp and diode in parallel for allowing the closed circuit to remain closed, hence maintaining thyristor 25 conductive, even during the repeated open circuits across the buzzer 24 caused because of its particular mode of operation. The lamp gives indication of when the circuit is closed, in addition to providing a continuously-closed current path. A gate resistor and gate condenser, for improving the rate of change of voltage with time, dv/dt, of the thyristor 25 in the circuit being used, are connected between the gate and cathode of said thyristor 25. The ends of the reed switch 9 are connected one end to each, to the buzzer 24 and the gate of the thyristor 25 in said circuit of said alarm indication unit 21, and when the magnet 8 on the side of said tire is excited and the reed switch 9 is closed, a current flows in the gate of the thyristor 25 which thereupon becomes conductive so that said closed circuit conducts current and the buzzer sounds thereby indicating a pressure reduction in the tire. Further, with the rotation of the tire, the magnet 8 meets face-to-face with the reed switch 9 once every rotation, so that the operation of the reed switch 9 becomes intermittent but in the thyristor 25, once a current flows in the gate, by its special character, the anode and cathode of the thyristor 25 conduct irrespective of the presence of the gate current and a continuous operation of said buzzer 24 is caused. Thereupon, when a pressure reduction in the tire has been indicated and is noticed, the closed circuit can be opened by pushing the switch 23 and thus the alarm operation stopped.

Next, an alarm indication system for use in a four-wheel vehicle will be described with reference to Figure 5. In a plurality of tires in general, various indication systems can be considered but an alarm indication system is shown wherein the front and rear tires on the right of the vehicle are monitored together and the front and rear tires on the left of the vehicle are monitored together. In this system a pressure detection unit 1 and a signal transmission unit 7 are mounted on each wheel and tire assembly of the four-wheel vehicle. In the electric circuit of an alarm indication unit 21^1 are an electric lamp 26 for indicating that source 22 is operating correctly and an alarm lamp 28 which can replace the alarm buzzer 24 on the operation of a changeover switch 27. The gate side of a thyristor 25 is connected to the units on the left and right hand sides of the vehicle through diodes 29A, 29B respectively. The units on the right and left

hand sides of the vehicle are provided with pilot lamps 30A, 30B and thyristors 31A, 31B respectively, for alarm purposes. The reed switches 9A, 9B associated with the right and left hand tires respectively are separately connected to the alarm indication unit 21^1 and when either of the front and rear tires on the left side of the vehicle is reduced in pressure to or beyond a predetermined value, the lamp 30A in the alarm indication unit 21^1 lights up and at the same time the buzzer 24 sounds thereby indicating the pressure reduction. When a tire on the right hand side of the vehicle is reduced in pressure to or beyond a predetermined value, the lamp 30B lights up and at the same time the buzzer 24 sounds thereby indicating a pressure reduction. A change over to the lighting of the lamp 28 instead of the buzzer 24 is possible by operation of switch 27.

Next, in Figure 6, a tire pressure bleed element 34 is fitted to a tire valve 33 mounted on a tire 32 and said element 34 is connected, by means of a conduit pipe 36, to a pressure detection mechanism part (B) provided on a wheel hub 35.

Figures 7, 8 and 13 show the construction of the pressure detection mechanism part (B). At the connecting point between the conduit point 36 and a pressure sensitive unit 37, a bolt 36*a* secured to the end of the conduit pipe 36 is secured to a threaded part 38*b* of an annular connection element 38 having a projecting part 38*a* and shown in detail in Figure 13. The bolt 36*a* has a hole 87*a* communicating with the bore of the pipe 36. The connecting point is kept airtight with the pressure sensitive unit 37 by means of an O-ring 89 conveniently provided at the end of the threaded portion 38*c* of the bolt 36*a*. The projecting part 38*a* provided in the annular element 38 is adapted to be fitted in a groove 39 provided in the pressure sensitive unit 37 and the groove 39 and projecting part 38*a* are so designed that an opening 40*a* of a hole 40 in said pressure detection unit 37 coincides with the hole 87*a* in the bolt 36*a*.

Within unit 37*a* member 42 bears on a diaphragm 41 so as to move together with the diaphragm 41 in response to tire internal pressure changes. The diaphragm 41 divides unit 37 into two chambers and is supported by a spring bearing 43 and a spring 44 housed in one of the chambers. The spring bearing 43 has a conical seating recess at its centre in which is engaged an adjustable supporting screw 45 and even if the spring bearing 43 and the spring 44 move to an inclined position due to vibration or rotation at the time of adjustment, they will still move smoothly without having an adverse influence upon the movement of the diaphragm 41.

Hence, in the pressure sensitive unit 37, when the tire internal pressure decreases to or below a predetermined value, the pressure in chamber 46, which communicates *via* a hole 47 and hole 40 with the tire, decreases to the new value also and the diaphragm 41 is deformed by the spring 44 towards the direction of lower pressure, whereby the member 42 moves in the same direction and pushes a blade spring lever 48. A permanent magnet 49 is fitted to the extreme end of the lever 48, and when the lever 48 is so pushed the clearance between this permanent magnet 49 and a reed switch mounted on a non-rotary part of the wheel is reduced so that the reed switch 50 closes and thus an alarm device unit (not shown in Figures 7 and 8) is energised *via* a lead wire 51.

By this alarm, the pressure reduction in the tire is indicated. When the tire pressure is increased by introducing more air into the tire, the pressure in the chamber 46, *via* the holes 40 and 47, is also increased and, when the tire internal pressure exceeds the predetermined value, the diaphragm 41 becomes deformed in the opposite direction against the spring 44 whereby the member 42 also moves in that direction so that the lever 48 is returned by its inherent resilience to its Figure 7 position and the reed switch 50 is therefore opened to de-energise the alarm device unit.

In the third embodiment as shown in Figure 9, a housing 54, containing both a pressure sensitive unit and a permanent magnet, is fitted to the tire wheel rim 53 having a tire 52 thereon so that the pressure sensitive unit is inserted within the tire 52. A reed switch 55 is secured to a backplate 58 of a brake drum 57 by means of a bracket 56. The switch 55 is located adjacent to the rotational path of the housing 54. As shown in Figures 10 and 11, the housing 54 comprises a cylindrical body 60 open at one end to the tire pressure and fitted at its other end to a further body 59, there being a spring 61 arranged in cylindrical body 60 with one end bearing on a shoulder therein. The other end of the spring 61 bears on a plate 62 adjustably secured by a nut 63 to one end of a rod 64 which is arranged within the spring 61. The other end of the rod 64 is provided with an abutment which is connected to one side of the diaphragm 65 sealing the body 60 from the body 59. A member in the form of a pin 66 is secured to the other side of the diaphragm 65 so that the pin 66 is reciprocable by the diaphragm 65 according to the tire pressure to which the body 60 is open. The components 60 to 66 constitute the pressure sensitive unit of the present embodiment.

A body 67 of the housing 54 is secured by a screw thread, from the outside of the wheel rim 53, to the body 59 located on the

tire side of the wheel rim 53. A shaft 68 is provided in the body 67 so that it is arranged perpendicular to the pin 66. A groove 69 is provided in the shaft 68 for latching engagement by the pin 66 when the diaphragm 65 is displaced against spring 61 by air pressure within the tire at or above the predetermined value. A permanent magnet 70 is mounted on the extreme end of the shaft 68 outside the wheel rim 53. A spring 71 is arranged so that the shaft 68 is biased in the direction of said extreme end and a rubber cup 72 of the housing covers the open end of the body 67. A projection 68*a* is provided on the shaft and is fitted in a groove 59*a* provided in the body 59 to prevent rotation of the shaft 68 and magnet 70. When the tire pressure falls below the predetermined value the diaphragm 65 is moved to retract the pin 66 from the groove 68 to permit movement of the magnet 70 to the Figure 11 position by the spring 71.

The reed switch 55 is provided at a position adjacent to the path of the permanent magnet 70.

The tire pressure detection unit of Figure 9 to 11 is connected to an alarm indication unit 73 as shown in Figure 12. There are four detection units each of which is associated with one wheel of a four-wheel vehicle. The units of the left hand side wheels are paired together and the units of the right hand side wheels are also paired together. In the electric circuit of the alarm indication unit 73, a switch 74, an electric source lamp 75, and a lamp 77 for replacing a buzzer (not shown in the drawing) by means of a changeover switch 76, are connected together with left and right pilot lamps 78A and 78B. When either of the front and rear tires on one side of the vehicle decreases in pressure to or below a predetermined value the appropriate pilot lamp in the alarm indication unit 73 lights up (for instance, when a tire on the left hand side of the vehicle decreases in pressure, the pilot lamp 78A lights up), and at the same time the buzzer sounds or the lamp 77 instead of the buzzer lights up and thus a tire pressure reduction to or beyond the predetermined value is indicated.

Figure 14 shows in detail the tire internal pressure bleed element 34 of Figure 6. The element is substantially cap-shaped and a threaded part 93 is provided for connection with the valve 91 of the tire 90. A projection 96 is formed at the centre of the element and a bore 97 is formed in the projection 96. The bore 97 communicates with a chamber 94 containing a filter 95 and being provided inside the bleed element. A connector 98 connected to the conduit pipe 103 is airtightly fitted to the bleed element by means of a packing 98*a* in a manner such that the chamber 94 communicates with the connector 98 through a small orifice 99.

When the bleed element is screwed onto the tire valve 91, the projection 96 depresses a valve stem 100 in the tire valve 91 so that the valve core (not shown in the drawing) is opened and the air in the tire flows to the pressure sensitive arrangement 37 of Figures 7 and 8 through the conduit pipe 103.

Since the bleed element must be airtightly mounted, the tire valve 91 and the bleed element 92 are kept in airtight interconnection by means of a packing 101, and the connector 98 is airtightly secured to the bleed element through the packing 98*a*. A lock nut 102 secures the tire internal pressure bleed element 34 to the tire 91 to prevent loosening of the element 34 during rotation of the wheel. The size of the orifice 99 is such that even if the conduit pipe or other parts connecting the element 34 to the arrangement 37, excluding the tire, is or are damaged, the air pressure in the tire is not suddenly decreased, and the filter 95 is provided to prevent the orifice 99 being choked up with dust or the like from the interior of the tire.

WHAT I CLAIM IS:—

1. A tire pressure indication system including: a pressure sensitive arrangement contained wholly within a vehicle tire or arranged outside the tire and in gaseous communication with an inflation valve of the tire, the pressure sensitive arrangement comprising a diaphragm arranged to move when the tire pressure changes and a member connected with the diaphragm so as to be moved when the diaphragm moves; a signal transmission unit comprising a magnet arranged to be controlled by said member, the pressure sensitive arrangement and the magnet being mounted for rotation with the tire and the signal transmission unit also comprising a reed switch for arrangement on a non-rotatable part of the vehicle adjacent to the rotational path of the magnet; and an alarm indication unit for location in a driver's compartment of the vehicle, said alarm indication unit incorporating means for alarm indication and an electrical circuit having a thyristor, said alarm indication unit being connected to said reed switch which is operable, when arranged as aforesaid and when the tire is rotating, to be closed by said magnet to operate said thyristor and thus the alarm indication means in response to movements of said diaphragm and consequently said member caused by a pressure reduction in the tire to or below a predetermined value.

2. A tire pressure indication system according to claim 1, wherein the pressure sensitive arrangement further comprises a spring arranged at one side of the diaphragm for biasing the diphragm.

3. A tire pressure indication system according to claim 1 or claim 2, wherein the pressure sensitive arrangement is contained wholly within the vehicle tire and the magnet is an electromagnet coupled to a switch arranged to be operated by movement of said member, there being a battery housing mounted for rotation with the tire and having a contact operable to close by centrifugal force on rotation of the tire so that, when a battery is present in the housing, a current is fed to the magnet to energise the latter at the time of a pressure reduction in the tire to or below said predetermined value during rotation thereof; said switch operated by said member, said battery housing contact and said magnet being electrically connected in series.

4. A tire pressure indication system according to claim 1 or claim 2 wherein the magnet is a permanent magnet.

5. A tire pressure indication system according to claim 4 when appended to claim 2, wherein said member is arranged so that, when said predetermined value is passed going down or up, the magnet will move either into an operative position in which its path is close to said reed switch or into an inoperative position in which its path is remote from the reed switch respectively.

6. A tire pressure indication system according to claim 4 when appended to claim 2, wherein the magnet is carried by a spring loaded reciprocally mounted shaft provided with a recess which is engageable by said member to retain the shaft and magnet in the inoperative position until the tire pressure falls to or below said predetermined value, and wherein the biasing force on said diaphragm from said spring is adjustable.

7. A tire pressure indication system according to claim 5, wherein the pressure sensitive arrangement is mounted away from the tire and is connected to the inflation valve of the tire *via* a conduit pipe.

8. A tire pressure indication system according to claim 7, including a cap-shaped bleed element having a screw-threaded part engageable on the tire valve and a central projection provided with a bore therein communicating at one end with the interior of the tire and at the other end with a chamber containing a filter, there being an orifice leading from said chamber which orifice is connectible to said conduit pipe.

9. A tire pressure indication system substantially as hereinbefore described with reference to Figures 1 to 4, or Figure 5, or Figures 6 to 8 and 13 and 14, or Figures 9, 10, 11 and 12, of the accompanying drawings.

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Printed for Her Majesty's Statioffery Office by Burgess & Son (Abingdon), Ltd.—1974.
Published at The Patent Office, 25 Southampton Buildings, London WC2A 1AY,
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9 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG. 1

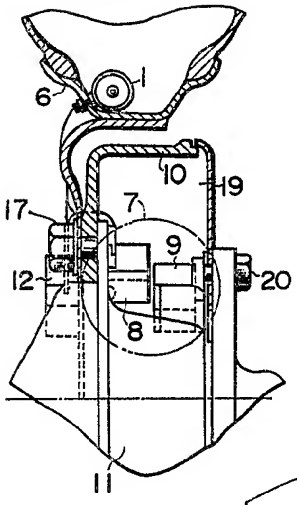

FIG. 3

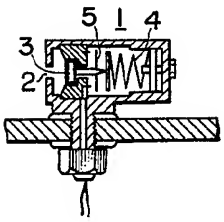

FIG. 2

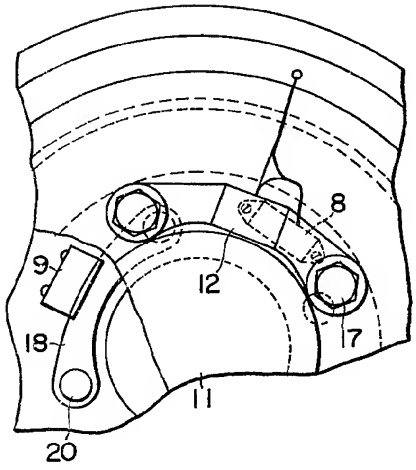

FIG. 4

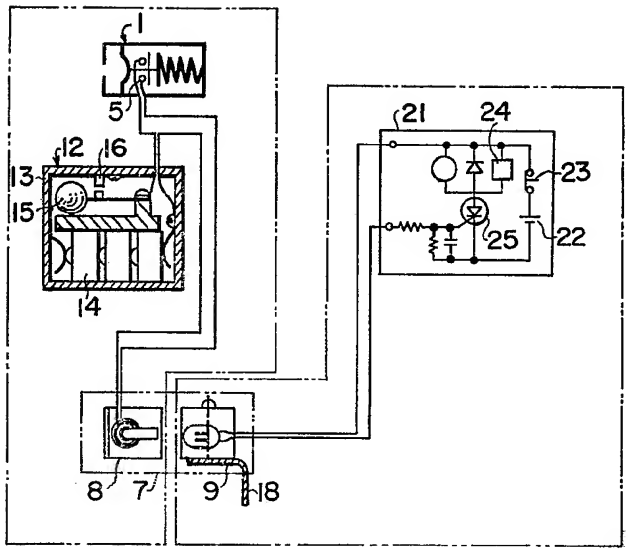

FIG. 5

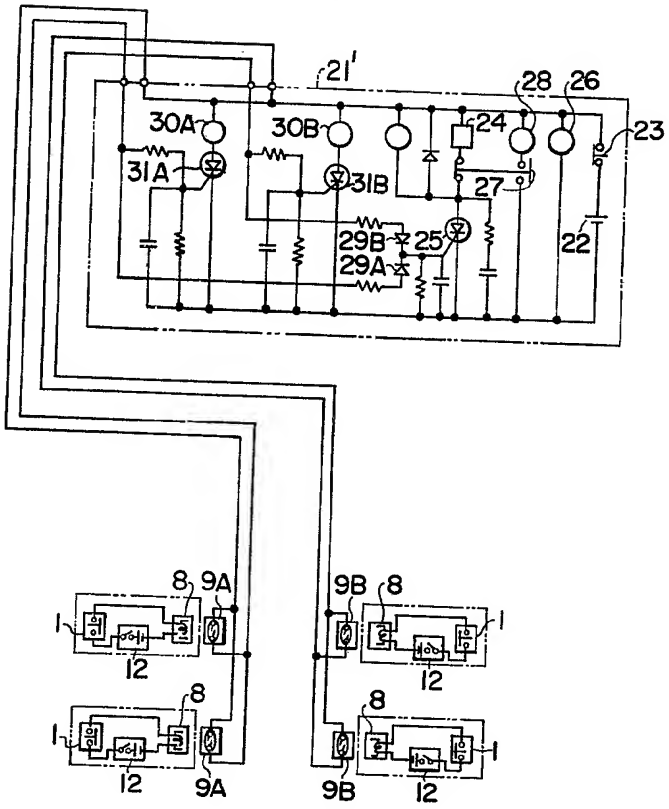
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FIG. 6

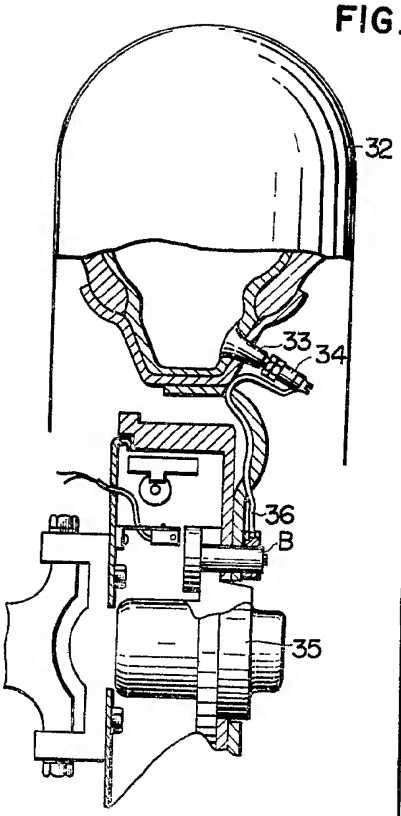

FIG. 9

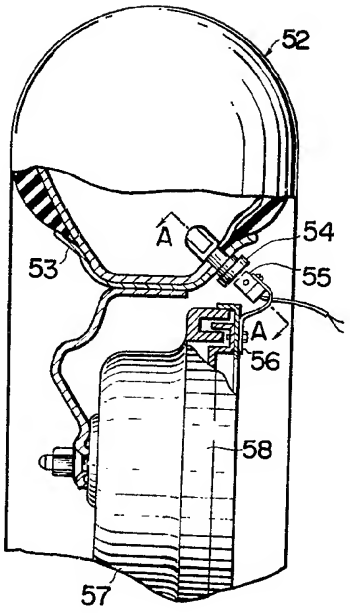

FIG. 7

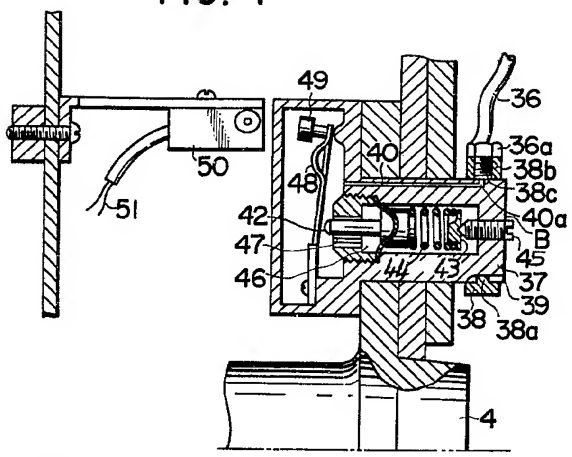
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FIG. 8

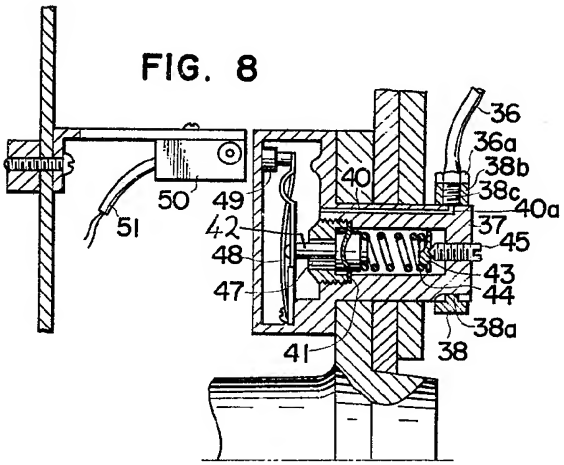
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FIG. 10

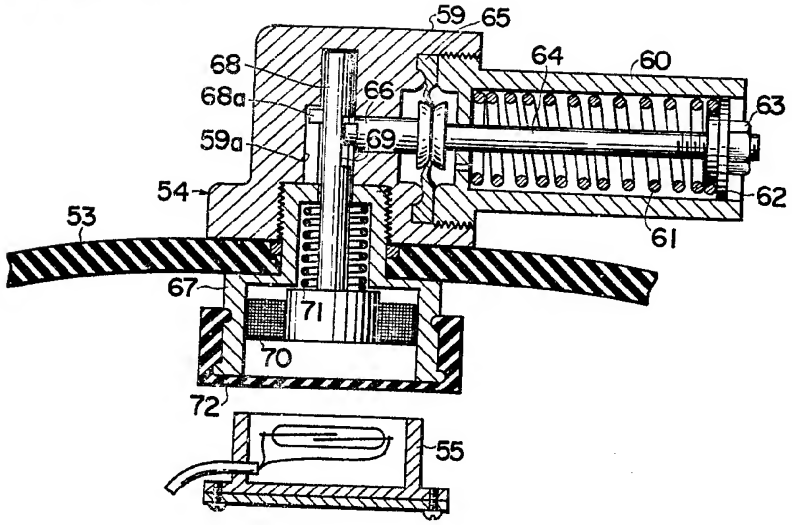
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FIG. 11

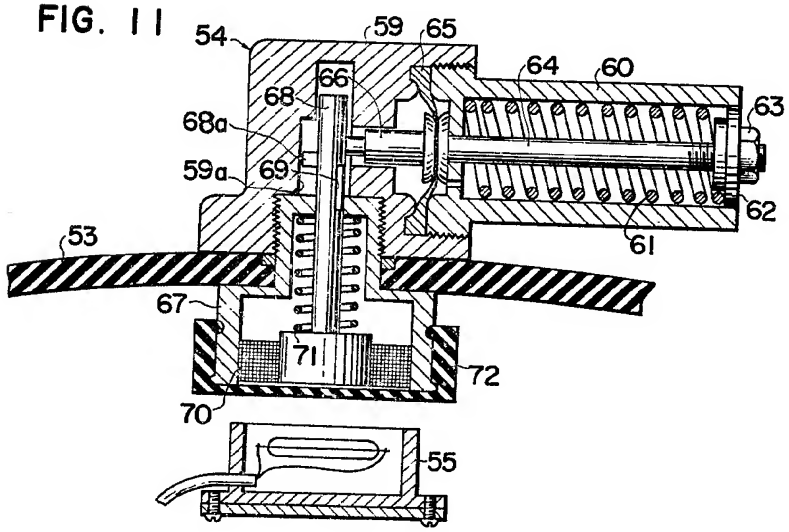
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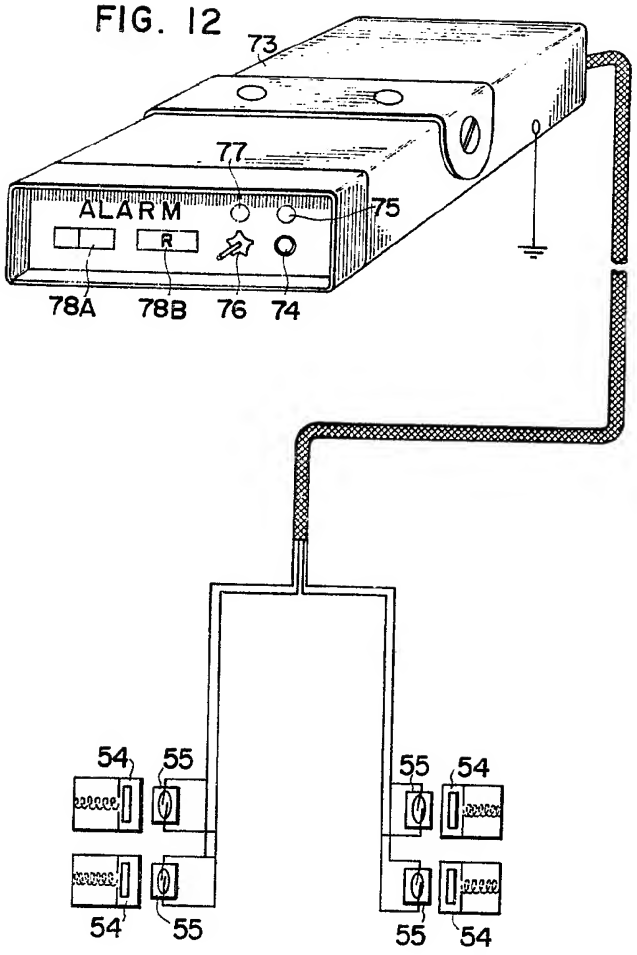
FIG. 12



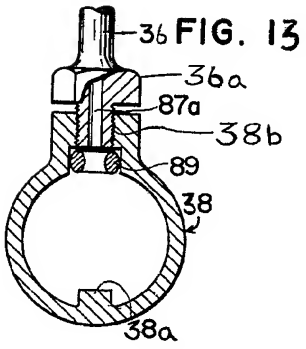


FIG. 13

FIG. 14